# Biotechnology in Developing Countries: An Overview

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Many problems need solutions in "developing," or "newly industrialized," countries. In developing countries, lifestyles include a significant involvement in food production and marketing. Hence, like developed countries the primary objectives of agricultural research are those that can be readily applied to meet the needs of the farmer, industry and consumer. However, there is less opportunity for chemical and physical intervention of biotechnology in agriculture or for medical and veterinary applications. The difficulty lies not in identifying problems, but in deciding in concept where biotechnology can quickly provide appropriate solutions. The purpose of "Symposium XI: Biotechnology in Developing Countries" is to present successful examples of developments and accomplishments that are making quality contributions to developing countries in two areas—(1) "Suitable Bioengineering Processes"; and (2) "Stimulating Biotechnology for Small-scale Farmers." These areas include discussions on educating researchers in advancing their developments of biotechnology at the farming, industrial, marketing, and political sectors.

The opening presentation, "Marine Biotechnology and the Third World: Research and Applications," by R.A. Zilinskas, analyzes areas of marine biotechnology that are particularly relevant to developing countries. Island countries and countries with long coast lines have barely drawn on their marine capital, probably for many, the Earth's richest assets. Measures are suggested whereby developing countries can build their capabilities in marine technologies. Biotechnology is defined as "a set of scientific techniques that use living organisms, or parts of organisms such as cells, to make or modify products, to improve plants or animals, or to develop organisms for specific applications." Areas for advancement in marine biotechnology include aquaculture, marine natural products, bioremediation, biofilm-bioadhesion, cell culture, biosensors and terrestrial agriculture.

In Latin American Countries, biotechnology is having an impact on most of the essential products produced. J.F. Allende notes in "Biotechnology Efforts in Latin America," that one reason for these advances is the large critical mass of scientists in many different scientific and technological disciplines collaborating in efforts to advance biotechnology research. Latin American countries have recognized the advantage of pooling resources. Additionally, a large number of international and regional agencies have come together in collaborative programs with Latin America countries. This has greatly strengthened industry-science contacts and advanced research in human resource development, multinational programs and biosafety guidelines.

"Scope and Some Applications of Biotechnology in Developing Countries—Case Study of Saudi Arabia," by D. Alani, discusses efforts to apply biotechnological techniques for inexpensive solutions to selected problems. Like most developing countries, Saudi Arabia has large amounts of bioresources that provide opportunities for bioconversion into needed products. The country also has major issues with petroleum resources (that carry a risk of

environmental pollution) and a limited water supply. Examples of research include (1) date palm propagation and use of this fruit as a source of antibiotics and cellulosic materials; (2) use of refinery wastes, oily sludges, tank residues and oil contaminated soils; and (3) applications of microorganisms for wastewater treatment and agricultural applications.

The successes of the Republic of China, Taiwan, in land reform, agro- and food-based industries, capital intensive manufacturing and technology-based developments have led this country into the age of high-technology electronics and computers. D.G. Mou, in "Development of the Biotechnology Industry in Developing Countries: The Taiwan Experience," shows biotechnology designated as essential to this country's industry, society and environment in the 21st century. Successful programs are emerging in hepatitis B vaccine production. The establishment of a Development Center for Biotechnology is underway and planned is a new Pharmaceutical Research and Development Center to meet the biotechnology challenge. A strategy is being developed to expand and transform the country's primarily market and domestically oriented and fragmented bio-industry into one that is technologically sophisticated and globally oriented.

Studies to advance biotechnological developments in the newly industrialized country, Korea, by immobilizing hybridoma cells that produce monoclonal antibodies are presented by H.N. Chang in "Continuous Production of human Chorionic Gonadotropin (hCG) Monoclonal Antibody in Various Membrane Bioreactors." Cells were immobilized and cultivated within dual hollow fiber Ca-alginate capsules and cylindrical depth fiber bioreactors. In the dual hollow fiber bioreactor, hybridomas were successfully cultured, and monoclonal antibodies produced, for two months. Hybridomas encapsulated within Ca-alginate gels had high monoclonal antibody production. However, a long term continuous culture could not be maintained because of the diffusion limitations of nutrients and wastes. A newly developed depth filter perfusion system, based on the immobilization of hybridoma cells within a cylindrical depth filter matrix, yielded a stable continuous culture producing high amounts of monoclonal antibody. This bioreactor is projected as a process for continuous large-scale production.

Jute, a lignocellulosic bast fiber source, is a cash crop of Bangladesh, India, Nepal, Thailand and China. Due to incomplete extraction of fiber from the plant, 20-40% of jute produced is of low grade because of excess hemicellulose. The conventional industrial methods use chemical and mechanical means to prepare spinnable fibers of limited quality. Efforts are underway in various research laboratories to improve jute fibers by biotechnological processes. One such approach is described by M. Hoq in "Enzyme Biotechnology in Developing Countries." This study revealed that *Thermomyces lanuginosus* could produce pH-stable and cellulase-free thermostable xylanase on inexpensive medium. The enzyme has potential for upgrading jute and other fibers. Studies are underway to develop suitable bioprocesses for enzyme production and industrial application.

In "Building the Base for Critical Mass of Biotechnological Scientists in a Developing African Country", A.I. Robertson explains that the first use of biotechnology in Africa is to improve agriculture. Low-technology applications use tissue culture techniques; high-technology, DNA manipulations; and industry, fermentation and downstream processes. Robertson states that "practicing agriculture provides the experience that a holistic approach is needed," i.e., in a developing country, if there is one weak link in agricultural production, the result can mean that there is no crop, no viability and sudden debt or starvation. This makes risk-avoidance a high priority. Hence, efforts should build a base and work toward technological competence. Organizational infra-structures must grow and along with them research breakthroughs should induce improvements that only fine-tune already established technologies. Examples presented include gene-transfer-induced improvements in selected crops.

A.S. ElNawawy states that there are biotechnological applications that have impact on the maintenance of soil fertility, sustaining increased agricultural productivity and improving farmers' profitability in "Impact of Biotechnology in Sustaining Food and

Agriculture in Developing Countries." Examples include biofertilizers for legumes and non-legumes, organic matter recycling for composting and ensilage of mushrooms, and feed production through solid state fermentation. Biogas technology provides a way of supplying alternative fuels from available farm wastes. Earthworm biotechnology can lead to improved soil fertility. Bioremediation of contaminated soils and water is one technology that is available for removing/metabolizing toxic substances so that soil can be reused. New crops that are thermo-tolerant, salt tolerant, resist pesticides, and fix nitrogen are imminent through recombinant DNA and tissue culture techniques.

Crop production by small farmers in the Philippines and other developing countries is hampered by poor soil fertility and the high costs of chemical fertilizers. Microorganisms such as mycorrhiza have been tapped as alternatives to chemical fertilizers. R.E. dela Cruz presents five such developments in "Applications of Mycorrhizal Technologies for Agriculture and Forestry." These technologies increase the survival, growth, and yield of agricultural crops, especially in adverse sites of marginal fertility. Vesicular-Arbuscular Mycorrhizal (VAM) fungi have been shown to replace 65-85% of the chemical fertilizers required for crop growth.

J.P. Moss, in "Constraints to Production in the Semi-arid Tropics—Can Biotechnology Help the Small Farmer?" notes that the climates of the world's semi-arid tropics are harsh with inadequate, uncertain rainfalls, usually infertile soil, high incidences of pests and diseases and low availability of investment capital. Biotechnology offers the hope of introducing agricultural cultivars that can overcome these restraints. Biotechnology also offers breeders, pathologists, entomologists, and physiologists ways of speeding the breeding process (via *in vitro* regeneration, haploids, and micropropagation), increasing the precision of screening (restriction fragment length polymorphism, polymerase chain reaction and other markers) and improving the diagnosis of diseases (enzyme-linked immuno-solvent assay, monoclonal antibodies). The potential for achieving breakthroughs is greatest when scientists in developed and developing countries cooperate to make the best use of facilities and resources.

"On-farm Anaerobic Treatment of Agricultural Wastes in Some Countries in Asia," by W. Tentscher, examines the progress in the design of small-scale fixed-dome digesters and of medium and large scale biogas plants for processing agricultural wastes. China and India are among the leaders in the development of biogas technologies. Modern methods are being applied to determine structural stability of the digesters and maximum process performance. Progress is occurring in mathematical modelling of kinetic reactions and computer technologies. As a result, ability to assess the economic implications of changes in technical parameters has improved. A new pilot project in a medium scale pig farm in Thailand, employing the Hybrid Plug-flow, High-rate digester system for diluted wastewaters with suspended solids is being introduced on-farm. Biogas technology, be it at small farms, feed lots, or sewage treatment plants is gaining increasing attention. With these processes, $CO_2$ and mineral-organic matter can be recycled.

In "developing" or "newly industrialized" countries, biotechnology research in agriculture is growing in importance. This is in spite of the difficulties that sometimes occur in deciding, in concept, where biotechnology can quickly provide appropriate solutions to meet the immediate needs of the farmer, industry and consumer. Critical masses of scientists and engineers in many different disciplines collaborating worldwide are contributing to these solutions. The results are technological competence and risk-reduction in the application of biotechnological developments, so important to many developing countries. Hence, biotechnological breakthroughs being realized in developed countries are also occurring in "developing" or "newly industrialized" countries at a level directed to immediate needs.

**References**

Ninth International Biotechnology Symposium and Exposition; "Harnessing Biotechnology for the 21st Century"; August 16-21, 1992; Crystal City, Virginia, USA.